RAPORT ŞTIINŢIFIC FINAL
PN-III-P4-PCE-2021-0595

3. The most significant results

The electromagnetic response in ^{56}Fe nucleus has been investigated by a theoretical approach incorporating the energy-density functional (EDF) and three-phonon quasiparticle-phonon model (QPM) theories with special emphasis on electric (E1) and magnetic (M1) dipole excitations located below the neutron threshold, as shown in Figure 1. The QPM calculations are made in a multi-phonon model space built of natural and unnatural parity states of one-, two-, and three-phonon (microscopically described) configurations with J^π ranging from $1^\pm$ to $6^\pm$ and excitation energies E_x up to 10 MeV, in agreement with the range of the NRF experimental data.

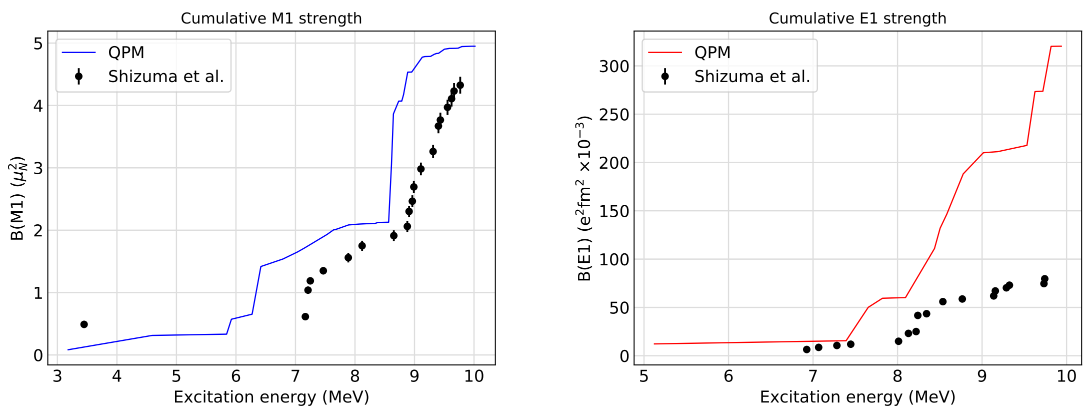

Figure 1: Running sums of E1 and M1 strengths up to E_x=10 MeV in ^{56}Fe: EDF+QPM (solid blue line- M1 and solid red line- E1 summed strengths, respectively) and the (γ, γ') experiment. (black dots with error bars).

We have carried out an experiment at CCB Krakow to study the decay of the M4 resonance state in ^{12}C located at 19.5 MeV by employing high-energy proton inelastic scattering. This resonance is a stretched state namely it arises from single-particle excitations dominated by a single particle-hole component for which both the excited particle and the residual hole occupy the highest angular-momentum orbitals j_p and j_h in their respective shells, and couple to $J_{\max} = j_\mathrm{p} + j_\mathrm{h}$.

At RCNP we have performed the first experiments within this collaboration on ^{10}B, ^{11}B, ^{12}C, ^{13}C, ^{27}Al which will be continued under accepted proposals at RCNP on ^{16}O, ^{26}Mg, ^{40}Ca and ^{56}Fe. A target vacuum chamber dedicated to the PANDORA measurement was designed to be compatible with the γ-detector setup. Mechanical support, feed-through connectors for extracting the detector signals, mechanical support of preamplifiers and the entire vacuum chamber are included. A target control system used for E498 in the Scγlla setup was used to insert a target ladder and control its position from the top of the vacuum chamber. Eight large volume $LaBr_3$ detectors (3.5"ϕ-8" L) from Milano were configured in the Scγlla setup, and with the PANDORA chamber, we could accommodate SAKRA.

We have performed several experiments at the ROSPHERE setup at IFIN-HH, one of the major results being the first observation of an M3 transition in ^{10}B, which has been analysed and published in *Phys. Rev. Lett.*, see Figure 2.

In total, we have produced 10 scientific papers that are either published or submitted for publication, 2 review papers that have been published, we have participated in 12 scientific conferences

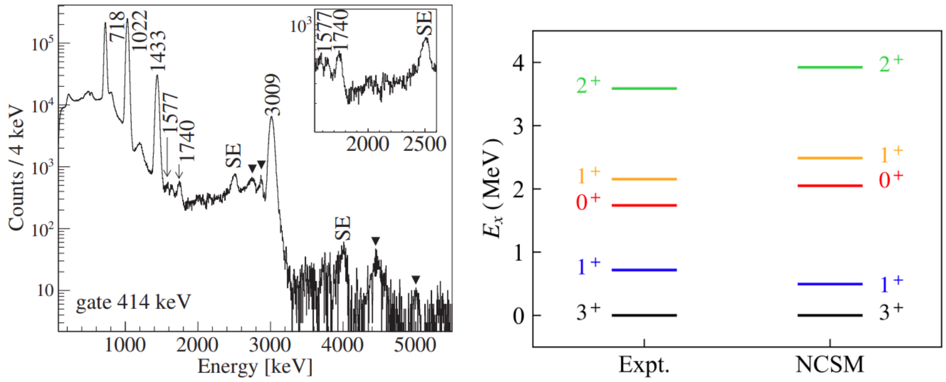

Figure 2: (Left) The γ-ray spectrum observed in coincidence with the 414 keV γ-ray transition of ^{10}B. The ^{10}B γ rays are labeled with their energies. The peaks marked with the triangles indicate contamination. (Right) Experimental bound excited states of ^{10}B compared with the NCSM calculation with the newest version of the local position-space chiral N3LO NN force. A. Kuşoğlu, et al., Phys. Rev. Lett., 133 (2024) 072502

and workshops, we have performed 6 experimental campaigns with promising results, meaning that significantly more results will come after the closing of this project. For the current results, we have organised several workshops where one of the major topics of the workshop in November 2024 was organised with a focus on the impact of the results. The measured results are now implemented in reaction codes and used by the ultra-high energy cosmic-ray (UHECR) propagation theory community to improve our understanding of the photodisintegration of these particles. Figure 3 shows an example of this implementation.

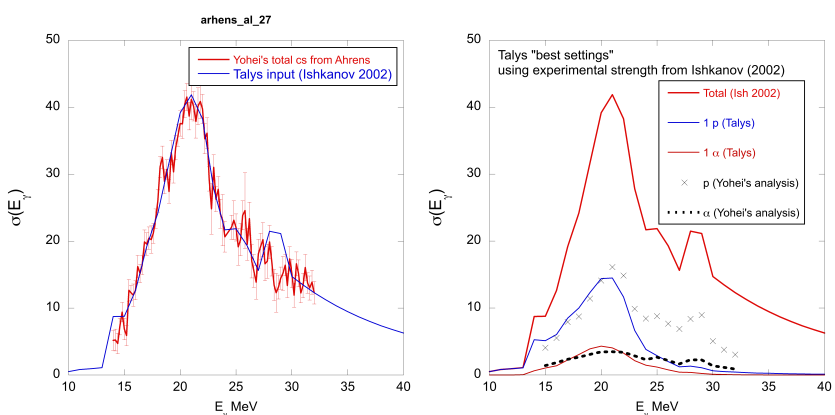

Figure 3: (Left) Our experimental data of the total photoabsorption cross-section in the case of ^{27}Al compared to previous data. (Right) Our branching to charged-particle decay channels compared with the best setting of the TALYS code that has been fine-tuned to the experimental data [D. Allard, private communication].

In summary, we have completed the planned research in accordance with the project application and the Technical Progress Reports.